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[0001] The invention relates to a method to the production of covalent bonded biological active substances at polyurethane foams as well as the use GET rising up ores of the polyurethane foams for chiral syntheses.

[0002] The production of polyurethane foams by conversion of polyisocyanates with compounds with at least two reactive hydrogen atoms as well as other auxiliary and additives is for a long time known and became multiple described. Major ones become as polyurethane foams hard and soft foam used. Depending upon targeted application become preferred thereby open celled or closed cellular foams.

[0003] A recapitulatory revue over the production from polyurethane foams e.g. becomes. in the plastic handbook, band VII, "polyurethanes", 1. Edition 1966, edited of Dr. R. Vieweg and Dr. A. Höchtl, as well as 2. Edition, 1983, and 3. Edition, 1993, in each case edited of Dr. G. Oertel (Carl Hanser publishing house, Munich), given.

[0004] Enzymes become used due to its selectivity and high catalytic activity in rising extent in the food, Pharma and chemical industry. Technological disadvantages with the use of enzymes consist in particular of the fact that these frequent separated not satisfactory because of their substrate solubility from the reaction medium to become to be able. Beside the loss exerted by it at these expensive biocatalysts additional expenditures result from corresponding required Reinigungsprozesse.

[0005] By a suitable immobilization of the water-soluble enzymes series of advantageous effects can become achieved:

light separable of the biocatalyst (enzyme) from the reaction solution;
Recyclable GET rising up ores of the enzyme (reduction of the specific catalyst costs);
no post treatment (deactivation, purification) of the feed required;
continuous processing possible (process control improves)

[0006] In EP-A-0562371 and EP-A-0562373 the immobilization biochemical substances, in particular becomes described of enzymes. In the comparison to the physical adsorption of enzymes, becomes observed with which a light desorption of these enzymes, made during a covalent enzyme adjustment a substantial steadier connection attaching between substrate surface and enzyme molecule. This connection attaching becomes after these EP realized by the fact that an unsaturated epoxyfunktionelles polysiloxane becomes crosslinked on a carrier material applied and. The enzyme becomes bonded thereafter covalent over the so introduced epoxy groups.

[0007] After DE-A-4131546 lipase at a commercial available carrier (Eupergit C - Röhm Pharma Germany) over present epoxy groups becomes covalent linked. With the help of the so immobilized enzyme chiral alcohols are to become generated.

[0008] In US-A-4342834 an enzyme becomes bonded when retention or increase its catalytic activity to a polyurethane. The enzyme becomes preferably from aqueous solution with the polyurethane in contact brought, before the polyurethane one foams. With foamings it is then made certain that by the reaction heat no denaturation of the enzyme occurs.

[0009] In EP-A-0089165 experiments of Japanese authors become cited, cells of a cell suspension with the help of a commercial available prepolymer (HYPOL, company Grace) bottom formation of a foam, which contains these immobilized cells to bring to the reaction. These so obtained foams exhibit in particular an unsatisfactory mechanical resistance, which leads to technological problems. As solution the immobilization at a crosslinkable Polyazetidinprepolymeren becomes mentioned.

[0010] After EP-A-0859051 enzymes become to water-insoluble polymers, the quaternary amino group inertial, fixed.

[0011] In WO-A-9746590 and -9746267 various methods become the immobilization of bioactive materials mentioned. On a carrier first a layer of a polymere surface-active material becomes applied. This applied material becomes with the help of a crosslinker in International Telecommunication Union crosslinked. As crosslinkers become among other things Vinyl compounds, imidazoles, Epoxide, isocyanates, anhydrides etc. mentioned. On this layer in the long run a second layer of an hydrophilic polymer becomes applied and in such a way linked with the base layer. The bioactive molecule is tied over the second layer.

[0012] In DE-A-19653669 Trägermatrices with reactive groups (activation become among other things by glutaraldehyde, cyanogen bromide, Imidazolderivate) mentioned, with which immunoglobulins from biological fluids separated to become to be able.

[0013] After CA-A-1264898 will attempted to produce using gelatin and aliphatic diisocyanates an enzyme connection at hydrophilic gels.

[0014] Wang and Ruckenstein (Biotechnol. Progr. 1993, 9, 661-65) used porous PU particles, in order to adsorb lipase first. By a conversion with glutaraldehyde attempted became to reach by the generated crosslinking a stabilization the real estate-sown.

[0015] O'Reilly and Crawford (Appl. and Environmental Microbiology, 1989, 2113-18) attempted with the help of a PU prepolymer (HYPOL) a cell suspension to immobilized, whereby mixed into this cases the suspension only with that prepolymers and the reaction brought becomes.

[0016] In US-A-3672955 water-soluble enzymes are mixed to the fixation with an isocyanate in aqueous solution, whereby still porous materials additional with used to become to be able. Over the so generated ureas the enzymes should be covalent bonded.

[0017] After CSU 1472503 an enzyme is adsorbed first to a silikatischen carrier (silochrome). The so prepared material becomes then subsequent in-foamed into a polyurethane.

[0018] In EP-A-0571748 the fact becomes discussed that Matrices from PU hydrogels exhibit good mechanical properties, which possess present free isocyanate groups however an high toxicity opposite biological materials. Thus a considerable characteristic damage is to be expected. Therefore will proposed to produce first a cutting of the isocyanate groups by a Bisulfittaddukt. This aqueous solution this Bisulfittadduktes becomes the cell mass given. This mixture is introduced in drops into a well alginate solution. The training Alginathülle works stabilizing and can become subsequent in a phosphate buffer detached.

[0019] Castle et al. (Angew. 157, (1988), 105-21) the production of particular synthetic polymers by suspension polymerization of vinyl acetate and N, N' Divinylethylenharnstoff describe macromolecular chemistry. After corresponding workup reactive epoxy groups at the polymer surface become the enzyme connection generated by conversion with epichlorohydrin.

[0020] Those the state of the art of corresponding suggestions quite permit in individual cases a certain immobilization of biological active species, which are however frequent with a waste of the catalytic activity linked. There is still another sufficient improvement potential. In particular it is required to develop solutions which permit it to bind both in anhydrous Mediums and from aqueous solutions and/or suspensions biological active species in particular over isocyanate groups at PU surfaces durably more bottom maintain the catalytic activity. With the fact ensured must be that the high toxicity of the isocyanate groups leads to no damage of the biological active species.

[0021] Object of the invention was it therefore to develop a method a durable fixation of biological active substances, In particular enzymes, at polyurethane foams possible, whereby a sufficient mechanical strength of the carrier material should be ensured. The so prepared biocatalyst polyurethane carrier composite should be more insertable with high selectivity in chiral syntheses, in particular with transesterification procedures.

[0022] This object could become surprisingly thereby dissolved that polyurethane foams became developed, the reactive groups at the foam material surface to exhibit and thus as carrier material for a durable fixation of biological active substances suitable is.

[0023] Subject matter of the invention are therefore a method to the production of covalent bonded biological active substances at polyurethane foams as well as such with biological active materials GET rising up ores of polyurethane foams themselves.

[0024] Subject matter of the invention is further their use for chiral syntheses.

[0025] We found with our studies surprisingly that with use of polyurethane foams, which contain reactive groups at the foam material surface biological active materials on the foam material surface anchored and thus immobilized to become durable to be able, without these lose their activity. The result according to invention was therefore surprising, since with a too strong development of a covalent bond on the danger it is to be counted that that becomes catalytic active center of the enzymes damaged. In the sequence the activity sinks. With a too weak covalent bond it comes to a deactivation due to detachment of the enzyme of the carrier.

[0026] Particularly favourably and surprising is that applying the biological active materials can take place on the carrier in the aqueous Mediums. This saves significant expenditures. To expect it would have been that the reactive NCO groups present on the foam material surface were deactivated by the water.

[0027] According to invention the polyurethane foams used for the purpose become in conventional way by conversion of organic and/or modified organic polyisocyanates (A) also opposite isocyanates reactive hydrogen atoms exhibiting compounds (B) in presence of auxiliary and additives (C), prepared. The for this insertable starting materials and process conditions become other bottom more near described.

[0028] Preferably polyurethane rigid foam or - becomes according to invention semihard foam materials used, since these materials exhibit one for the intended use sufficient mechanical strength. It is however quite also possible to use softer foams.

[0029] Required the according to invention reactive groups at the foam material surface are in particular NCO groups. Beside the NCO groups can be as other reactive groups for example epoxy groups, acid groups and/or phenolic oh group present.

[0030] In order to produce required the according to invention reactive groups at the foam material surface to embody as it were in the foam stand different methods become applied. One can obtain the corresponding result for example by addition of, if necessary additional, amounts at suitable starting materials or by a subsequent soaking of the polyurethane foam with such cloths.

[0031] By control of the reaction conversion of the PU reaction reactive NCO groups at the foam material surfaces can become generated. In addition the portion of isocyanate groups becomes affected over the ratio from isocyanate groups to hydroxyl groups with the foaming, mostly as identification number referred. It proved thereby as favourable, if during the foaming of the polyurethanes an identification number >100, in particular >130, becomes used, in order to produce a sufficient number reactive NCO groups at the surface of the foam. Since during the sudsy reaction in particular the particularly reactive NCO groups, which have also the proven toxic effect for the biological active substances, the reaction brought to become to be able, shown it itself surprisingly that the so remaining isocyanate groups have a stepped reactivity, those the connection of the biological active compounds at the foam material surface accomplished, without causing a durable damage. Due to in such a way reduced reactivity, which becomes also by the glass transition temperature polymers of the certain, these reactive groups are available over a longer period. Their selectivity is also in aqueous environment sufficient large for the connection of the biological active species.

[0032] Favourable way should take place the subsequent treatment of the PU carrier provided with reactive NCO groups on the foam material surface to enzyme carrier composite according to invention more immediate after its production. If a longer storage is required, then it should become bottom humidity exclusion made, in order to thus prevent a reaction of the NCO groups with the water and a deactivation of the PU carrier.

[0033] Favourably it is also to produce by a subsequent soaking of the polyurethane foam with and/or polyisocyanates and subsequent conditioning additional reactive NCO groups at the foam material surface. Also isocyanates with different reactive NCO groups use can find. For this in particular the subsequent isocyanates are suitable: Diphenylmethane diisocyanates, Toluylendiisocyanate and Polyphenylenpolymethylenpolyisocyanat, in each case alone or in arbitrary mixtures among themselves.

[0034] For the soaking procedure the preferably open celled foam - particularly preferred after a previous Zerkleinerungsvorgang - with a solution of an isocyanate in an organic solvent becomes treated. After the removal of the solvent then a polyurethane with additional

isocyanate groupings at the accessible surface is to enzymes for the covalent connection attaching with biological active substances, as for example, at the disposal.

[0035] It has itself shown that brief keeping at a moderate temperature of the foam over approx. 1 hour with 80 DEG C with a subsequent application of a reactive diphenylmethane diisocyanate a positive influence on the presence of the reactive accessible NCO groups on the granular polyurethane material possesses. After the soaking process with this isocyanate the excess solvent becomes remote. More immediate after it can then the supernatant fermenter solution, which contains the biological active substances, with which so activated carrier material reacted become.

[0036] Apart from the isocyanate groupings can be other reactive groups, as for example epoxy groups, acid groups and/or phenolic oh group, present.

[0037] In some cases it is from advantage, if additional functional groups on the foam material surface are present, since thereby the connection of the biological active materials at the foam material surface can be improved.

[0038] By use of OH-functional Epoxiden reactive epoxy groups at the foam material surface can become generated. As OH-functional Epoxide for this for example infrage comes: Glycidol and 1-Hydroxybutylenoxid, preferably used become glycidol.

[0039] By use of acidic-group-supporting compounds reactive acid groups at the foam material surface can become generated. As acidic-group-supporting compounds for this preferably infrage comes: OH-functional acidic ones, as for example Glycidolsäure, hydroxybutyric acid, dimethylolpropionic acid and/or säuregruppenhaltige prepolymers, as for example NCO prepolymers on basis of diphenylmethane diisocyanate, polyole components and dimethylolpropionic acid. Particularly preferred used becomes Glycidolsäure and dimethylolpropionic acid.

[0040] By use of phenols, for example Mitverschäumen of corresponding starting materials or additional carriers, can become phenolic oh group at the foam material surface generated. As phenolic compounds for this preferably infrage comes: Calixarendervate, like e.g. C9- or C10-Calixaren. Particularly preferred used becomes C9-Calixaren.

[0041] It is particularly favourable to build Calixarene into the PU matrix. They are from high resistance and have the ability to fix if necessary as coenzymes suitable metal ions.

[0042] As Calixarene compounds use find among other things, like them in applied chemistry 107 (1995) 785-818 through V. Böhmer described are. Its synthesis based essentially on the conversion of various phenols or Resorcinderivaten and formaldehyde.

[0043] Beside, preferably according to invention the compounds mentioned used to the achievement of the result, also other reactive groups, as for example amino group, can be on the foam material surface present. Amino group can become for example generated, as free isocyanate groups at the surface of the foam with polyamines are saturated.

[0044] The amount of the reactive groups which can be applied on that PU-Inertial depends on the respective type of enzyme and the application conditions and can become by suitable simple tests adjusted.

[0045] The presence of the reactive groups on the foam material surface can be controlled by spectroscopic methods, in particular the IR spectroscopy. However also functional groups become displayed, which are the biological active substances if necessary not accessible. Very good suitable is a comparison experiment, which becomes bottom otherwise identical conditions with and without presence of the reactive groups conducted. With absence of such accessible groups it usually comes to a rapid activity waste of the enzymes.

[0046] For the execution of the invention process it is favourable, a polyolische component, which contains and usually as polyol component referred will those opposite isocyanates of reactive hydrogen atoms exhibiting compounds (B) and mostly also the catalysts, blowing agent necessary to the production of the polyurethane foams as well as other auxiliary and additives (C) to convert with the isocyanate component to a polyurethane foam. Favourable way the compounds with the reactive groups before that, which can be brought in, become foamings of the polyol component added. It is however also in principle possible to add a material with additional reactive groups of the isocyanate component.

[0047] It is also possible to realize after corresponding manufacturing of the PU carrier an additional application of the reactive groupings mentioned, for example by a soaking procedure with corresponding conditioning.

[0048] Appropriately the foam is to be cut up before on the desired particle size or the pore diameters is sufficient large to be produced, so that a soaking solution can reach also all parts of the solid surface.

[0049] The polyurethane foams according to invention are to exhibit one if possible large surface area for the contact with the biological active materials, which are to be fixed on the foam material surface.

[0050] The accessibility of the reactive sites can by an adjustment of the open celled of the foams or by a comminution of the polyurethane foams, e.g. over a meal process, generated become.

[0051] The adjustment of the open celled of the foams made for example by suitable cellopenable materials and use of commercial silicone stabilizers. Preserved one has itself an open celled of >90%.

[0052] Become comminuted foams used, used one favourable-prove grain size < 5 mm, whereby with to small grain size an elevated flow resistance in the reaction vessels is to be expected.

[0053] Further it can be favourable to adjust the polyurethane foams hydrophilic in order to ensure an optimum wetting of the foam with the reaction medium. The hydrophilicity of the polyurethane foams can become for example by the use of Polyetherolen with an high content at ethylene oxide in the chain elevated.

[0054] It is also possible to adjust the foams according to invention hydrophobic. One receives such hydrophobic foams for example by a preferred use from polyols with an elevated content at propylene oxide in the Polyetherkette. These foams have usually a good stand stability.

[0055] The described polyurethane foams according to invention with reactive groups at the foam material surface are suitable in particular for the covalent bond of biological active materials.

[0056] Bottom biological active material become products understood, which are able to activate biological processes. To it belong and are insertable to according to invention for example cell cultures, cell suspensions, microorganisms and in particular enzymes. They can be present for the application of this invention both and solid material or and solution or if necessary as suspension in an aqueous and/or an organic medium. Enzymes become provided in pure form or if necessary as supernatant fermenter solution from the fermentation from cell federations to the order. In particular enzymes are capable to chiral syntheses. A frequent applied synthesis is thereby the transesterification of suitable raw materials with as selective an yield at the desired chiral esters as possible. As enzyme becomes preferably applied thereby a lipase, which becomes by fermentation of *Pseudomonas Plantarii* recovered. After a corresponding freezing drying process this lipase is available as solid powder, whereby this preparation step is cost-intensive. Is from particular interest however a fermenter solution, which remains after the Abzentrifugieren of the cell material and which the enzyme which can be fixed contains in an aqueous suspension.

[0057] The production with biological active materials GET rising up ores of polyurethane foams made by Inkontaktbringen of the PU carrier with biological active materials, contained on the surface reactive groups, favourable-proves by mixing the carrier material with for example an aqueous enzyme hereditary peace. As Andockstelle preferably present reactive amino group of the biological active material serve. These can react with the reactive surface groupings of the carrier.

[0058] The enzyme carrier composite becomes subsequent separated and dried. It exhibits favourable-proves a swelling that GET rising up ores biological active materials of less than 10%.

[0059] With biological active materials GET rising up ores according to invention polyurethane foams in particular used become for chiral syntheses, in particular for selective transesterification reactions. Whole particularly preferred becomes Lipase polyurethanematerials. With this enzymatic esterification reaction very mild reaction conditions can become adjusted, which the use of thermosensitive materials allowed.

[0060] To the other charging products as well as auxiliary necessary for the execution of the invention process and/or additives in detail the subsequent one is to be said:

[0061] The production of the polyurethane foams of made usually hydrogen atoms exhibiting compounds (B) in presence of auxiliary and additives (C), reactive serving as carrier material, by conversion of organic and/or modified organic polyisocyanates (A) also opposite isocyanates.

[0062] As organic and/or modified organic polyisocyanates (A) the conventional and known (cyclo) aliphatic and in particular aromatic polyisocyanates used can become. Examples for (cyclo) aliphatic polyisocyanates are Hexamethylenediisocyanat-1,6 and Isophorone diisocyanate, examples for aromatic polyisocyanates are 2,4 - and 2,6-Toluylendiisocyanat (TDI), 4,4' - , 2,4' - and 2,2' - diphenylmethane diisocyanate (MDI), Polyphenylen polymethylen polyisocyanate (rawMDI), 1,5-Naphthylendiisocyanat. The isocyanates mentioned can be also modified, for example by incorporation of Carbodilimidgruppen. Frequent ones become the polyisocyanates also in the form of prepolymers used. It concerns reaction products of the polyisocyanates mentioned with polyol components. Mostly so called Isocyanatprepolymere becomes used, i.e. such reaction products of polyols and polyisocyanates, which exhibit free isocyanate groups at the chain end. The prepolymers and Quasiprepolymer and its production are well known and multiple described. For the invention process become in particular prepolymers with a NCO content within the range of 25 to 3.5 Gew. - % used. As polyols to the production of the prepolymers and Quasiprepolymer Polyetherole, in particular 2 - and 3-funktionelle ethylenoxid and/or propylene oxide attachment products with molecular weights of 1000 to 8500, become preferably polytetramethylene glycols with molecular weights of 500 to 3000, polyester oils with molecular weights within the range of 500 to 5000 and a functionality from 2 to 3, available by known conversion of polycarboxylic acids with polyfunctional alcohols, and/or Polycarbonatdiol with a molecular weight of 500 to 1000 used. The production of the prepolymers and Quasiprepolymer can become in presence or absence of conventional and known, also bottom component (C) described Urethanisierungskatalysatoren conducted.

[0063] In a preferable embodiment of the invention process become as component (A) TDI, MDI and/or rawMDI used.

[0064] As hydrogen atoms reactive opposite isocyanates exhibiting compounds (B) become preferably polyester oils and particularly preferred Polyetherole with a functionality from 2 to 8, in particular from 2 to 4 and preferably 2 to 3, and a molecular weight within the range of 400 to 8500, preferably 1000 to 6000, used. The Polyetherole can after prior art processes, mostly by catalytic attachment of alkylene oxides, in particular ethylene oxide and/or propylene oxide, at H-functional starting substances, or by condensation of tetrahydrofuranes, prepared become. As H-functional starting substances come in particular polyfunctional alcohols and/or amines to the use. Preferred used alcohols are dihydric alcohols, for example ethylene glycol, propylene glycol or Butandiol, trivalent alcohols, for example glycerol, trimethylolpropane or pentaerythritol, as well as alcohols with high order, like sugar alcohols, for example sucrose, glucose or sorbitol. Preferred used amines are aliphatic amines with up to 10 carbon atoms, for example ethyl diamine, diethylene triamine, propylenediamine, aromatic amines, for example Toluylendiamin or diaminodiphenylmethanes, as well as Aminoalkohole, like ethanolamine or Diethanolamin. As Polyetheralkohole also polymere-modified Polyetheralkohole can become used. These become mostly prepared by in International Telecommunication Union polymerization of olefinic unsaturated monomers, in particular acrylonitriles and/or styrene in the Polyetheralkoholen. To the polymere-modified Polyetheralkoholen also Polyharnstoffdispersionen contained Polyetheralkohole belong.

[0065] To the compounds with at least two active hydrogen atoms belong also the chain extension and crosslinking agents, which if necessary along-used to become to be able. As chain extension and crosslinking agents preferably 2 becomes - and 3-funktionelle of alcohols with molecular weights of bottom 400, in particular within the range of 60 to 150 used. Examples are ethylene glycol, propylene glycol, diethylene glycol and Butandiol-1,4. As crosslinking agents also diamines can become used. Case chain extension and crosslinking agent used become, preferably amount to their amount up to 5 Gew. - %, related to the weight of the polyol component.

[0066] The reaction mixture to the production of the polyurethane foams according to invention other auxiliary agents and/or additives become (C) added. Mentioned ones are for example catalysts, blowing agents, foam stabilisers, flame retardants, fillers, dyes, pigments and hydrolysis protective agents as well as fungistatische and bakteriostatisch acting substances.

[0067] As catalysts for the production of the polyurethane foams according to invention the conventional and known PU education catalysts preferably become used, for example organic tin compounds, like Zinndiacetat, Zinndioctoat, Dialkylzinndilaurat, and/or strong basic amines, like triethylamine, Pentamethyldiethylentriamin, Tetramethyldiaminoethylether, 1,2 Dimethylimidazol or triethylenediamine. The catalysts preferably become in an amount from 0,01 to 5 Gew. - %, in particular 0.05 to 2 Gew. - %, related to the weight of the polyol component, used.

[0068] As blowing agent to the production of the polyurethane foams preferred water becomes used, with the isocyanate groups bottom release of carbon dioxide responsive. Common ones with or at site of water know also physical acting blowing agents, for example hydrocarbons, like n, ISO or cyclopentane, or halogenated hydrocarbons, like tetrafluoroethane, pentafluoropropane, heptafluoropropane, Pentafluorbutan, hexadecimale fluorine butane or Dichlormonofluorethan, used become. The amount of the physical blowing agent preferably lies thereby in the region between 1 to 15 Gew. - %, in particular 1 to 10 Gew. - %, the amount of water preferably in the region between 0,5 to 10 Gew. - %, in particular 1 to 5 Gew. - %, in each case related to the weight of the polyol component.

[0069] By an appropriate selection of foam stabilisers, preferably used will silicone stabilizers, can the open celled of the polyurethane foams be affected. A reduction of the stabilizer portion of effected thereby a frequent pore enlargement.

[0070] Other indications over usable starting materials specified above and the other are for example in the cited above plastic handbook, band VII, polyurethanes.

[0071] With the production of the polyurethanes according to invention the polyisocyanates and the compounds with at least two hydrogen atoms in such an amount, reactive with isocyanate groups, become contacted that the equivalent ratio from isocyanate groups to the sum of the active hydrogen atoms 0,8: 1 to 3,0:1, preferably 1,2:1 to 2,0:1 amounts to, or with an isocyanate surplus like other described above processed.

[0072] The production of the polyurethane foams made preferably after the one SHOT method, for example with the help of high pressure or low-pressure technique.

[0073] It is particularly favourable to work in the conventional so called two-component procedure with which a polyole and an isocyanate component prepared and are foamed. The components become preferably with a temperature in the range between 15 to 90 DEG C, preferably 20 to 60 DEG C and particularly preferred 20 to 35 DEG C the reaction brought.

[0074] The polyurethane foams with reactive groups at the foam material surface, prepared after the invention process, preferably point a density from 10 to 800 kg/m³, particularly preferred from 30 to 100 kg/m³ and in particular from 30 to 80 kg/m³, up.

[0075] The improvement of the contact area with the respective Mediums the foamed bodies can become into geometric shapes brought (cube, balls etc.). Possible ones and meaningful are also linings of reaction vessels, tubes etc. By a corresponding variation of the cell size the required pump pressure can become with application of compact materials optimized.

[0076] Good suitable is the use of coarse-grained particles, which for example by Raspeln or meals of the polyurethane foams prepared to become to be able. These materials can e.g. into a reactor tube introduced become.

[0077] The instant invention is to become on the basis the appended examples more near explained.

[0078] As test reaction to the checking the enzyme-catalyzed esterification of 1-Phenylethanol with vinyl propionate served the efficacy of the lipase.

[0079] One proceeded as follows: The immobilized lipase became shaken with a substrate solution (see model reaction) staggered and with room temperature. The conversion became followed by means of gas chromatography. The maximum conversion amounted to 50 Gew. - %. After 24 hours filtered and the recovered lipase with new substrate became staggered and again shaken.

EMI15.1

MTB Methyltertiärbutyliether
ee Enantiomerenüberschuss

[0080] The used foam prescriptions are in the subsequent table summarized:

Columns=3		
Head Col 1:		
Head Col 2: System 1		
Head Col 3: System 2		
polyol 1	September	14
polyol 2	September	53
polyol 3	September	4,3
polyol 4	September	68,8
polyol 5	September	5
polyol 6	September	23,9
polyol 7	September	13
polyol 8	September	5
glycerol	September	1,4
Lupragen TM N600	September	0,3
DMCHA	September	2,5
TMR-2	September	0,1
VP 9104	September	1
B 8409	September	1
B 1903	September	0,7
B 8919	September	1
waters	September	2,4

[0081] As isocyanate component Lupranat served TM M20A in all cases (BASF).

Polyol 1 - Oh number 400 mg KOH/g, polyether alcohol on basis of propylene oxide, starter glycerol;
Polyol 2 - Oh number 240 mg KOH/g, polyester alcohol on basis of Phthalsäure anhydride;

Polyol 3 - Oh number 400 mg KOH/g, polyether alcohol on basis of propylene oxide, starter sucrose;
 Polyol 4 - Oh number 490 mg KOH/g, polyether alcohol on basis of propylene oxide, starter sucrose;
 Polyol 5 - Oh number 55 mg KOH/g, Polyetheralkohol on basis of propylene oxide, starter propylene glycol;
 Polyol 6 - Oh number 105 mg KOH/g, polyether alcohol on basis of propylene oxide, starter propylene glycol;
 Polyol 7 - Oh number 250 mg KOH/g, polyether alcohol on basis of propylene oxide, starter propylene glycol;
 Polyol 8 - Oh number 385 mg KOH/g, polyester alcohol on basis of adipic acid Phthalsäureanhydrid;
 Lupragen TM N 600 - Amine catalysts (BASF);
 VP 9104 - Catalyst (BASF);
 DMCHA - Dimethylcyclohexylamin (catalyst);
 TMR-2 - Amine catalyst (air Products);
 B 1903, B 8419, B 8409 - Silikonstabilisatoren (Goldschmidt);
 Lupranat TM M20A - NCO 31.6% Polyphenylenpolymethylen polyisocyanate;

Example 1 A (comparison)

[0082] Formulation 1 became with an identification number of 180 a foam reacted. This foam became in the ambient air three weeks stored and afterwards with a Raspel comminuted. IR-spectroscopic could be found a significant decrease of the reactive NCO groups.

[0083] The freeze dried lipase became brought in a suspension in Methyltertiärbutylether with the geraspelten foam in contact and approx. 15 minutes agitated. Afterwards the solvent became remote in the rotary evaporator. It became an enzyme loading of 5 Gew. - % adjusted.

[0084] The so prepared enzyme carrier composite became used regarding its activity with the chiral transesterification (see test reaction). To 2 passes it came to a significant activity waste.

Example 1 b

[0085] Formulation 1 became with an identification number of 180 a foam reacted. This foam became immediate comminuted after the production (without storage) with a Raspel.

[0086] The freeze dried lipase became brought in a suspension in Methyltertiärbutylether with the geraspelten foam in contact and approx. 15 minutes agitated. Afterwards the solvent became remote in the rotary evaporator. It became an enzyme loading of 5 Gew. - % adjusted.

[0087] The so prepared enzyme carrier composite became used regarding its activity with the chiral transesterification (see test reaction). To 20 passes it came to a significant activity waste.

Example 2

[0088] Formulation 1 became with an identification number of 110 a foam reacted. This foam became two weeks stored and afterwards with a Raspel comminuted. Before the fixation of the lipase the geraspelte foam for 1 hour was baked with 80 DEG C and then with a solution of Lupranat MI in Methyltertiärbutylether in contact brought (0.5 Gew. - % NCO groups additional on the PU surface). The solvent became after an agitating time of approx. 15 minutes of the PU-inertial remote.

[0089] Thereupon the freeze dried lipase in a suspension in Methyltertiärbutylether with the geraspelten foam in contact became brought and approx. 15 minutes agitated. Afterwards the solvent became remote in the rotary evaporator. It became an enzyme loading of 5 Gew. - % adjusted.

[0090] The so prepared enzyme carrier composite became used regarding its activity with the chiral transesterification (see test reaction). To 14 passes it came to a significant activity waste.

Example 3

[0091] Formulation 1 became with an identification number of 180 a foam reacted. After the foaming the polyurethane with a Raspel comminuted became more immediate. Before the fixation of the lipase the geraspelte foam for 1 hour was baked with 80 DEG C.

[0092] Afterwards a supernatant enzyme hereditary peace with the geraspelten foam in contact became brought and approx. 15 minutes agitated. Subsequent one became in the rotary evaporator the excess water carefully remote. It became an enzyme loading of 25000 U/g adjusted.

[0093] The so prepared enzyme carrier composite became used regarding its activity with the chiral transesterification (see test reaction). To 29 passes it came to a significant activity waste.

Example 4

[0094] Formulation 5 became with an identification number of 110 a foam reacted. Additional one was the polyolischen component 5 Gew. - % glycidol added. This foam became comminuted with a Raspel.

[0095] Thereupon the freeze dried lipase in a suspension in Methyltertiärbutylether with the geraspelten foam in contact became brought and approx. 15 minutes agitated. Afterwards the solvent became remote in the rotary evaporator. It became an enzyme loading of 5 Gew. - % adjusted.

[0096] The so prepared enzyme carrier composite became used regarding its activity with the chiral transesterification (see test reaction). To 6 passes it came to a significant activity waste.

Example 5

[0097] Formulation 5 became with an identification number of 180 a foam reacted. This foam became two weeks stored and afterwards with a Raspel comminuted. Before the fixation of the lipase the geraspelte foam with a solution of Lupranat became MI in Methyltertiärbutylether in contact brought (1 Gew. - % NCO groups additional on the PU surface). The solvent became after an agitating time of approx. 15 minutes of the PU-inertial remote. In a pre-aged step were 5 Gew. - % of a C9-Calixarenderivates analogous to the NCO Gruppenaufträgerung on the foam material surface applied.

[0098] Thereupon the freeze dried lipase in a suspension in Methyltertiärbutylether with the geraspelten foam in contact became

brought and approx. 15 minutes agitated. Afterwards the solvent became remote in the rotary evaporator. It became an enzyme loading of 5 Gew. - % adjusted.

[0099] The so prepared enzyme carrier composite became used regarding its activity with the chiral transesterification (see test reaction). To 10 passes it came to a significant activity waste.